CLASS EXPERIMENTS AND DEMONSTRATION APPARATUS.

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I propose in this paper to make some suggestions regarding demonstration apparatus and lecture experiments suitable for a beginners' class in Psychology. Now that psychological instruction centres in the laboratory, rather than in the library, it is but natural that the old lecture courses should be replaced by courses in which demonstrations, class experiments and the projection lantern figure as largely as they do in elementary physics or elementary zoölogy. While, however, we are all, no doubt, using our laboratories to help out our class exercises, there has not appeared in print, so far as I know, any discussion of topics or materials of lecture demonstration. We find 'demonstration chronoscopes' and the like in the instrument makers' catalogues; we pick up this and that device from a colleague and work out this and the other for ourselves. We take what is on the market, and supplement it by things that appeal to our special interests,—a set of illusion charts, or of number-form models, or what not; we also exhibit pieces, taken from the laboratory, that are not demonstration pieces at all, but may be examined after lecture by those who are especially interested. Not very satisfactory! A good lecturer will, of course, always preserve his individuality; he will have demonstrations and methods of his own; he will be constantly improving upon ready-made apparatus. Still, there ought to be a full set of ready-made pieces, available to those who desire it at moderate cost. For, on the one hand, there are certain experiments that every student of psychology has a right to expect, and to share in, however poor the equipment of the departmental laboratory; and, on the other, we cannot begin to improve till we have a basis to improve from.

When, therefore, the Chicago Laboratory Supply Co. expressed a wish, some two years ago, to make up a regular set

of demonstration apparatus that might be supplied complete to new laboratories and departments, I gladly promised to give the matter my attention. I am not able, at the present time, to make any final recommendations. I have, however, got together a mass of notes upon one thing and another, and the issue of this Commemorative Number seems the right occasion to make a beginning with my proposals. Only a small portion of the ground will be covered here. I hope, before very long, to publish a more comprehensive survey of the field; and I hope, also, to have a set of apparatus on the market by the autumn of 1904.

In considering the subject of class experiments, we must be careful to distinguish between experiments that are performed, psychologically, by the student, and demonstrations that are made to the class by the lecturer. If I set up for fixation an illuminated circle of colored glass, and my audience observe the consequent after-image; or if I blow a double bicycle-whistle, and the audience observe the resulting difference-tone: then the class experiment is a true psychological experiment. Each member of the class does his introspection, sees and hears or fails to see and hear, for himself. If, on the other hand, I set up a reaction apparatus on the lecturing table, take my own reaction time, and write the sigma on the blackboard, I have made a mere demonstration. The class has seen the hand of the large clock start, and seen it stop; but no one, save myself, has any idea of the contents of the reaction consciousness. I have even known a lecturer, after showing some simple stereoscopic slides, to put the stereoscope to his own eyes and describe the perception,—all in the happy assurance that he was experimentally illustrating a fact of psychology. Now demonstrations of this second sort have their usefulness. It is much better to bring a stereoscope with you into the lecture-room, to pass round slides, and to work out the construction of the instrument by a diagram, than simply to talk about the facts and theories of binocular vision. And, again, there are many cases in which true introspective work on the part of the class is impossible. If, for instance, I am demonstrating the method of minimal changes by tuning-forks, or the method of right and wrong cases by the sound pendulum, or the method

of mean gradations by three color-mixers with black and white discs, I can give opportunity for a few crude introspections, but I cannot, obviously, carry out the method in detail: I cannot, under the conditions of time and place, go through a full series of observations, or lead my hearers to analyze their method of judgment and appreciate the dangers of secondary criteria. All this we may grant. Having granted it, however, we must insist that, within or without the lecture-room, the only psychological experiment is the experiment that requires the student to introspect. It may be worth while to demonstrate the sphygmomanometer, but the psychological lecturer can do no more with it than the physiological. We are teaching psychology; and, for that reason, our aim and ideal must always be to make our class demonstrations, so far as may be, true psychological experiments. The student who enters the laboratory from a general lecture course should not be wholly innocent of the introspective attitude. When we are showing how things are done in psychology, we should say so clearly, and explain why we can do no better; but, whenever possible, we should call on the class to do psychology for themselves.

The demonstration apparatus which I have in mind are, then, apparatus which shall subserve this latter purpose: apparatus that shall standardise the conditions for such introspections as the lecture-room and the lecture-hour allow. In what follows, I deal only with quality of sensation. In this field, the instruments fall roughly into two groups, according as the sense appealed to is capable or incapable of 'action at a distance.' For sight and hearing, single, large pieces may be placed upon or above the lecture table. For cutaneous sensation, a separate instrument must be provided for every student or pair of students.

I. Visual Sensation.

We require, first, materials for the demonstration of the two great visual series, colors and brightnesses. This demonstration is most important: young students are, in my experience, astonishingly ignorant of grays and colors, and the statement that there are some six hundred distinguishable brightness qualities is, unless backed up by a demonstration, simple

Greek to them. The demonstation of grays is not difficult. We have the Marbe mixer, which can be made to give a slow-changing continuous series of brightnesses from Hering's cloth-black to his baryta white. We have, further, for a discrete series, the album of Marbe photographic grays which is listed by Zimmermann. Fortunately for laboratories with short purses, the latter demonstration is the better, as well as the cheaper of the two. As the album is opened out, the student is impressed by the large number of readily distinguishable qualities, and when it is fully open the extreme black and extreme white are present simultaneously in his field of vision. Of course, the number of grays shown is relatively very small. But the lecturer can go on to compare the photographic black with Hering's cloth-black: that, again, with the black of velvet; that again, perhaps, with the black of a lightless space (Kirschmann photometer tube, made of cardboard on a large scale); while the photographic white may be compared with Hering's baryta paper. But even taken by itself, the album makes a better demonstration than the mixer.

In the case of colors, we are not so fortunate. It is really surprising—and it is this sort of lack that justifies the present paper—that no dealer in artists' supplies has lithographed a 'psychological spectrum.' We have the Prang spectrum chart: useful enough, but psychologically incomplete, because it does not give the purples, and psychologically unfair, because of the uneven space distribution of the various qualities. We have also the Prang Standard of Color: useful, as giving an idea of the immense number of visual qualities, but again incomplete, and too small for lecture purposes.[1] A 'psychological spectrum' (the term is unhappy, but seems to have made its way into current terminology) would consist of four bands of color, the one running from red to yellow, the next from yellow to green, the third from green to blue, the fourth from blue through purple to red. For demonstration purposes, at any rate, there can be no objection to having these bands of equal length.

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[1] I am not blaming the Prang materials for failing to serve a purpose that they were never intended to serve. They are, as I have said, very useful in a psychological laboratory. But they were not designed for psychological ends.

They should be printed upon stout cardboard, and so hinged together that the 'spectrum' can either be shown as a single line, or bent upon itself to form a complete square. The separate strips might well be 15 cm. in height and 30 cm. long. In the meantime, until something of the kind is manufactured, the lecturer will find it worth while to provide himself with a set of four hand-painted strips, over which slides a black cardboard cover, with adjustable vertical windows.

Our second problem is the separate demonstration of the three moments in a color sensation,—color-tone, saturation and brightness. We want to show that each one of these factors may vary while the other two remain constant. The apparatus that naturally suggests itself is the color mixer. Some form of color mixer is to be found in every laboratory, so that the advantages of the instrument need not be discussed here. I may, however, mention that I have now in course of construction a demonstration mixer, consisting essentially of a horizontal shaft, running parallel with the front edge of the lecture table and driven by a motor beneath the table, which by means of a set of friction plates may be made to turn, at any required rate of speed, one or more of six discs (large size Hering or Zimmermann) arranged along the table at 30 cm. intervals. I shall publish a full account of the apparatus later. It is obviously a great convenience to have six demonstrations ready, at the beginning of a lecture (the discs may be screened till they are required by the lecturer), and to be able, by a mere turn of a handle, to throw this or that or all the mixers into play. The apparatus has the further advantage that one's assistant can be adjusting a new set of discs to mixers 1 and 2 while one is showing discs 5 and 6, etc.: a good deal of time is lost, where two or three mixers only are used, in the unscrewing and resetting of the discs.[1] I may add a word of caution. The compound discs employed in demonstration must be put together before the lecture hour. Be sure, then, that they are tested by the assistant a short time before the lecture

[1] Sometimes a demonstration must be given twice, at either end of the apparatus. The angle under which an equation is observed by the audience may make a great difference in the result of the demonstration.

begins! The color mixer is, in general, a safe demonstration: the equations that hold for your own normal eyes will hold well enough for your audience. But I have seen a lecturer entirely nonplussed by the fact that his equations, made up on the preceding afternoon, refused to equate during the morning lecture.[1]

To return to the problem: I am accustomed to begin this set of demonstrations by keeping brightness constant while color-tone and saturation vary. To this end, I first mount a light color, say yellow (small disc), and a black and white (large discs), on a single mixer. On another mixer I mount a dark color, say green (large disc), and a black and white (small discs). I then show, by making my gray very much too light and very much too dark in both instances, that it is possible to estimate the relative brightness-values of a color and a gray, and therefore possible to equate these values. I next set the black and white of the first mixer to a brightness-match with the yellow: the match, which I have verified beforehand for my own eyes, will hold for at least a good part of the audience. Then, on a third mixer, I show the green *plus* white matched with the gray which has just matched the yellow. The equation, again, will hold for a good part of the audience. Finally, on a fourth mixer, I show the two matched colors, the yellow and the whitish-green. The brightness-values are the same; color-tone is different; the papers may be so chosen either that the saturation is also plainly different, or (if the lecturer prefer) that it is now sensibly the same. The contrast effects of the experiment are negligible. No more knowledge is required of the class than that black and white mix to make gray, and that the addition of black or white to a color darkens or lightens it.

To keep color-tone constant while brightness and saturation

[1] I have tried to make out, empirically, by noting the results of laboratory practice, the range of variation of the colored-paper components of a color equation. The different papers of a set differ so much and in so many different ways that it is difficult to lay down even an approximate rule. It is, however, safe to say that, up to three component papers, the change of illumination (summer and winter, morning and afternoon) may condition a variation of 10%.

vary, it is only necessary to add in different amounts of black, white, or black and white to a disc of a given color. Two mixers are sufficient for this demonstration. The appreciation of differences of brightness, as distinct from differences of saturation, is rendered possible by the result of the foregoing demonstration.

To keep saturation constant, while color-tone and brightness vary, I usually take a standard yellow, and a hard, staring blue. The blue is very much the richer, more saturated color. I add to the blue more and more of a dark gray (little white with a good deal of black), until the class begins to recognize that the two saturations are approaching equality. I then set the blue-gray mixture at the point which I have previously determined as the point of equal saturation, and show it and the yellow side by side. Color-tone and brightness are obviously different; saturation will be, for the majority of the audience, sensibly the same. Two mixers suffice again for this demonstration.

Theoretically, it should be possible to reverse these demonstrations: to vary one of the three components while keeping the remaining two constant. Practically, the reversal has been made only in the case of saturation. By using a Kirschmann disc,[1] one can show all degrees of saturation of a color-tone, without changing the brightness-values. If the laboratory possess a set of Hering grays, it is not difficult to find a paper that shall match a color in brightness; the color leaf may then be pasted directly upon the gray ground, and the making of the disc is much simplified. It would, doubtless, be possible to construct, empirically, a disc that should show one tone and one degree of saturation, while the brightness-values of concentric rings increased or decreased from center to circumference, and to construct a disc of uniform brightness whose concentric rings should show different color-tones of the same saturation. So far as I know, however, these discs have never been made.[1]

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[1] This *Journal*, VII, 1896, 386; IX, 1898, 346.

[1] Since this paper was written, I have devoted some odds and ends of time to the theory and practical construction of the discs. I have also had some correspondence with Dr. Kirschmann about them; and

So much for preliminaries. We come, in the third place, to the demonstration of the laws of color mixture. I have treated this subject fully in my *Laboratory Manual*, and have nothing of importance to add in this place.[1] I will only mention that, in all my experience of colored papers, I have never been fortunate enough to find a pair of ready-made complementaries, except in the single case of blue and yellow. Hence I am compelled to demonstrate the first law of mixture directly by aid of these qualities alone.[2]

Fourthly, there are the demonstrations of local adaptation and after-images. For color after-images, I know of nothing better than the Wundt demonstration apparatus. For local

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I hope that we may shortly be able to publish a joint note upon the subject.

[1]Vol. I, S. M., 5 ff.; I. M., 9 ff. I have here omitted to say anything as to the best method of cutting paper discs for the mixer. We employ (and I believe that the manufacturers follow a similar method) two discs of copper, turned accurately to the right size, and pierced at the center. The paper is laid between the discs, and trimmed around the edge with scissors.

[2]I cannot be sure that we have tried, in the Cornell Laboratory, every available combination; but we have certainly tried a very large number,—and always, save in this one case, without success. If any of my colleagues can suggest other complementary pairs, I shall be grateful for the information.

I may say that the references to colored papers in the literature seem to me greatly to overestimate the permanence of the colors. Colored papers change their color—certain components fading out more quickly than others—even in the course of a few weeks. In some cases there must be an intrinsic chemical change in process; compound equation discs that I have laid away in the dark have proved, after a lapse of some months, to be worthless for their original purpose. Hering's cloth-black fades noticeably in a very few days: an annoying thing, when one is doing quantitative work!

If the lecturer has the time—and the materials—it is worth his while to supplement the mixer demonstrations by the mixture of solutions, as recommended by N. von Klobukow (Vorlesungsversuch zur Demonstration der Wirkung von Complementärfarben und Farbengemischen beim Zusammenbringen von gelösten Farbstoffen, Wiedemann's *Annalen*, xliii. [cclxxix.], 1891, 438). The procedure is admirably suited to bring out the difference between mixture of pigments and mixture of sensations—or psychophysical excitations. The reference, curiously enough, has escaped the notice of the *Zeitschrift* bibliographers.

adaptation and brightness after-images I employ the following arrangement. A large wooden frame, roughly 75 cm. across by 120 cm. high, is hung upon the blackboard above the lecture table. The frame is painted of the same dull black as the blackboard, and its lower half is faced with a thin board similarly blackened. At the back of the upper (open) half of the frame is fastened a sheet of dark gray cardboard (68.5 cm. across and 56 cm. high). The upper and lower halves are separated by a narrow horizontal shelf, which is concealed behind the upper edge of the blackened front, and which can be turned down by a catch at the side. Standing upon this shelf, and running in grooves cut in the vertical sides of the frame, is a framed cardboard,—the right hand half covered with Hering cloth-black, the left hand with brilliant white paper. At the center of the line of junction of black and white is placed a white-and-black ivory button, for fixation. The demonstration runs its course as follows. The black and white card is placed upon the shelf, and the class fixates the button for 30 sec. During this time the white and the black tend both alike towards a neutral gray; this change, and the intense black and white after-image borders due to slips of fixation, are noticed by all. At the end of the 30 sec., the catch is released; the shelf turns down; the black and white card drops behind the blackened front upon a layer of felt laid at the foot of the frame; and the class sees the complementary after-images form upon the dark gray background. The apparatus admits of demonstration to at least 250 students.

For contrast there is nothing better than the Hering window. It is quite easy so to regulate the lights that the contrast color shall be pronounced the richer, more positive, more saturated color of the two,—though, of course, a reference to the backgrounds will indicate at once (to one who thinks!) which is the 'objective' and which the 'subjective' color. Unfortunately, the window requires a dark room, and is not in any case adapted for demonstration to a large audience. My dark room adjoins the lecture room, and I pass my students through, in groups of 15, during the last quarter of the lecture hour, while other demonstrations are given at the lecture table by an assistant. The window affords, without any question, the most striking

demonstration in the whole field of visual sensation. For desk demonstrations, we may have recourse once more to the mixer. Helmholtz discs[1] may be prepared in great variety, and with judicious choice of colors and gray may be made to give brilliant contrast effects. The amount of contrast may be indicated by setting up, on a second mixer, a disc of the contrast color (colored paper with black and white) which has been matched to the induced color immediately before the lecture hour. This quantitative demonstration, however rough, is valuable: the number of degrees of objective color necessary to reproduce the contrast effect is oftentimes surprisingly large. I also give demonstrations of Meyer's Experiment. A sheet of colored cardboard is nailed to a stout wooden frame, and a sheet of tissue paper (weighted below with a strip of cardboard, so as to hang evenly) is gummed to its upper edge. The frame is hung upon the wall behind the lecture table. Strips of gray cardboard are slipped in between the tissue paper and the colored background. The tissue paper may be turned up (by the cardboard strip along its lower edge) without creasing. In this form, the apparatus is relatively permanent; the same colored backgrounds and tissue sheets may be used for several years. If several thicknesses of tissue paper are affixed to the same frame, it is possible to show that the contrast effect is not (as is still erroneously held in some quarters) a function of diminished saturation.[2]

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[1] *Phys. Optik*, 1896, 544.

[2] Since writing the above, I have had the following apparatus constructed. Four sheets of Hering paper (red, yellow, green, blue) are pasted smoothly upon sheets of metal set flush with the front of a heavy black wooden frame. The papers are arranged from left to right in the order given; they are placed with the longer side vertical, and are about 7.5 cm. apart. Running horizontally across the centre of frame and colored spaces is a squared groove, in which can be laid a hard-wood bar, faced with a selected quality of gray paper. A lighter frame, with four tissue-paper windows is hinged to the upper edge of the main frame, and shuts down closely over gray bar and colored sheets. The bar can be shown upon the lecture table, and the uniformity of its gray facing seen by the audience. It is then placed in the groove, and the lighter frame locked down over all. Despite the differences of brightness and saturation of the four colors, the contrast effect, if the gray has been carefully chosen, is extremely well-marked.

Sixthly come the phenomena of indirect vision. These I demonstrate, very crudely, as follows. A strip of manila paper, 25 cm. high and about 2 m. long, pasted firmly to a wooden frame, is hung horizontally at a convenient height on the wall behind the lecture table. A black fixation-cross is painted at about 15 cm. from either end of the paper strip.[1] A light wooden rod, of the same color as the paper, carries discs of colored paper, 6 cm. in diameter. The class fixates the crosses alternately, with the appropriate eye, and the discs are moved slowly out and in along the manila strip. Rough as it is, the demonstration works very well,—and I do not know that anything else is required of a demonstration. In this, as in most other cases, I have upon the lecture table various laboratory appliances of the more refined sort: in the present instance, more particularly, an accurate perimeter, which I 'demonstrate' in a physical way. I am now concerned, however, with experiments which the students perform for themselves.

The effects of color blindness are shown, seventhly, by the aid of Holmgren worsteds. I keep two sets of these wools permanently arranged as they were sorted by two partially color blind observers, and hold up the matched skeins to the class. This is, in my experience, a better demonstration than can be made with colored charts. Actual tests for color blindness are taken, not with the worsteds, but with the Hering apparatus.

Lastly, the Purkinje phenomenon is demonstrated, as Sanford recommends, by requiring the class to observe a selected red and blue with nearly closed eyes.[2] The demonstration is more convincing if the papers are carried from daylight into a dark room, or if the lecture room is gradually darkened; but a partial closing of the eyes answers very well.

II. Auditory Sensation.

We ought to begin, in the domain of hearing, with demonstrations of simple tone and simple noise. Unfortunately, the psychology of noise is still in a very unsettled state; we do not

[1] This apparatus may also be used for demonstration of the blind spot.

[2] *Course in Experimental Psychology*, 1898, 142.

know, as yet, whether there is a series of simple noises whose qualities differ from those of tone, or whether the 'pitch' of a noise is always identical with the pitch of a tone. Of the analysis of complex noises, except in temporal regard, we know practically nothing. All that one can do, then, as a first demonstration, is to set off a single noise against a single tone: I use a dull thud (such as is made by the drop of a leaden ball upon a leaden block) and the tone of a blown bottle. I then point out the tonal character of certain apparently simple noises: the snap of the finger against the ball of the thumb, the pop of a cork drawn from a phial, the stroke of a wooden hammer upon a block of wood,—employing in the two latter cases a series of bottles of different sizes, and the blocks of a xylophone. I then take the hiss (from a pipe or a Galton whistle) and the clatter (from a toothed wheel), and point out that the former is not, while the latter is, capable of introspective analysis. Next, I contrast the tone (tuning-fork, blown bottle) with the clang (reed, string), promising a future discussion of clang-tint. Finally, I show how a clang may be generated from noises (toothed wheel) and a noise from clangs (group of tonometer reeds or piano keyboard). This is all rather unsystematic; but we can hardly do more until knowledge has advanced beyond its present stage.

The second set of demonstrations deals with the range of tonal hearing. For the upper limit of tonality, one may use small forks, steel cylinders, or a Galton whistle. From the lecturer's point of view there is, I think, little to choose between these three sources, though I personally prefer the forks. The lower limit can hardly be demonstrated; the tones are too weak. I show every year the large Kœnig fork, whose vibrations can usually be seen from all parts of the lecture room, the Appunn lamella, and the Appunn wire forks. These last make the best demonstration; the vibrations of the larger forks are clearly visible, and some of the higher tones can generally be heard in the front part of the room.[1] For discrimination of pitch I em-

[1] Whether these forks can still be obtained I do not know. Their stems are made of some alloy, which is very brittle: the forks do not give perceptible overtones, but are apt, as an offset, to break in two at the handle. I have had the set reproduced in steel wire. The new

ploy both a pair of Appunn forks with riders, and a tonometer with 4 vs. intervals. The latter makes a very satisfactory demonstration.

To demonstrate clang-tint, it is advisable that the lecturer have at his disposal a representative collection of musical instruments,—and be able to play them. Especial attention should be given to what Külpe terms, somewhat misleadingly, 'clangs of indefinite pitch' (cymbals, triangle, drum).[1] Whether clang analysis be undertaken (sonometer string, with or without resonators) depends on the size of the class. It may be demonstrated by help of the Ellis harmonical, or the Appunn *C*-box and overtone apparatus. I explain clang relationship by means of a large Mach model of the piano keyboard. Two strips of wood, of the same length as the keyboard and carrying black squares at the points indicating the first dozen overtones of the lower *C*, run in grooves above the keyboard. The strips can be set for any pair of primaries, and the degree of direct relationship is shown by the place of coincidence of overtones.

The best 'universal' apparatus for demonstrations in tonal psychology is, without any question, the new-pattern Stern variator, actuated by the Whipple double gasometer. The variator is made by F. Tiessen, of Breslau; a set of four bottles can be obtained for a reasonable price. The new pattern does away with the inconvenience of quicksilver, and the apparatus is much more compact and manageable than it was at first. I have had the Whipple tanks rebuilt, with metal frame and valves, and have mounted them upon a wheeled platform. The new model takes up less room than the old, is more sightly, and can easily be moved from room to room of the laboratory. I expect to publish later a cut and description of this whole arrangement. In the meanwhile, there are cheaper and more accessible demonstration pieces. For the continuous tone series, one may borrow a siren from the physical laboratory. For beats, one may use cheap forks, vibrating over

forks are much more durable than the old; but many of them gave a shrill overtone, which must be cut off by a cloth sleeve like that furnished with the Appunn lamella.

[1] *Outlines*, 304.

wide-mouthed bottles. For difference tones, one may use pairs of Quincke tubes, or a double bicycle whistle, or the Kœnig wheel and tube apparatus. This latter I have had built in a much lighter aud handier form than the original instrument, which is needlessly heavy and clumsy.[1] For fusion, one may use the Quincke tubes, or forks, or the keyboard of a piano or harmonium or harmonical, or the Appunn interval apparatus. But all these purposes, and several others, are subserved by the Stern variator. Since this is, at the same time, a research instrument, it is, literally, an apparatus that no well-equipped laboratory can afford to be without. It is at least as valuable, in psychological acoustics, as is the multiple color mixer in optics.[2]

III. Cutaneous Sensation.

For the demonstration of pressure spots I employ a simple instrument devised by von Frey. It consists of a stout horsehair, waxed into a short bit of narrow-bore glass tubing, the ends of which have been smoothed in the flame of a Bunsen burner. Very little time and no particular skill are required to make up a hundred of these instruments, and by help of them the whole class can readily verify the existence of pressure spots, say, upon the back of the hand, and can appreciate the character of the pure sensation of pressure.

Cold spots may be found by passing the blunt point of an ordinary lead pencil slowly across the back of the hand. As, however, one cannot be sure, in these days of fountain pens, that every student has a pencil, it is better to make express provision for the cold as for the warm spots. I use long wire nails (the sort that the carpenters call 'spikes'), rubbed to a rounded point. These are kept in ice water or warm water, as the case may be, and are handed round by an assistant. In

[1]Any of the Cornell apparatus described in this paper may be obtained, at cost of time and materials, from the laboratory mechanician, Mr. F. A. Stevens,—though I cannot guarantee speedy delivery. A selected set of demonstration apparatus will, as I have said above, be presently put on the market by the Chicago Laboratory Supply and Scale Co.

[2] The demonstration of the proper tone of the auditory passages, easily made by a piston whistle, is always interesting to a class.

the great majority of cases they hold their temperature long enough for demonstration purposes. Cold spots are easily discovered. I am not very sure about the warm spots. The best region to explore is the surface of the upper eyelid. But introspection of warmth sensations is difficult: the spots are less strictly circumscribed than the cold and pressure spots, and the sensation of warmth rises less quickly to its full intensity than do the other sensations. No doubt, the more accurate observers definitely obtain or as definitely fail to obtain pure warmth sensations. But I have thought at times that some of my hearers found their warmth spots out of complaisance to the lecturer. At any rate, the demonstration is one to be conducted with caution.

I make no attempt to demonstrate the existence of pain spots during the lecture hour. Nor do I appeal to anything but simple introspection for the analysis of the cutaneous-kinæsthetic complexes. Lecture table demonstrations may be made; but I know no practicable way of putting the class to work along with the lecturer.

IV. Taste and Smell.

Demonstrations in these fields are very difficult. It is worth while, perhaps, to provide the class with small mirrors, for the identification of the taste papillæ, though this is hardly a psychological demonstration. It may be worth while to call some member of the class to the lecture table, to blindfold him and stop his nostrils, and then to show the confusion of various 'tastes:' but I have known this demonstration to result rather in embarrassment on the part of the observer and hilarity on the part of the class than in any definite contribution to the psychology of taste on either side. Indeed, whether one can do anything by way of demonstration with tastes depends almost entirely upon the size of the class.

The same thing is true of smell. It is not difficult to make up half a dozen sets of phials, containing scents from Zwaardemaker's nine classes;[1] but to make up and to keep in order fifty such sets require more trouble than the lecturer will be willing to expend upon the demonstration. The olfactometer

[1] See my *Laboratory Manual*, i, I. M., 127 f.

is best kept upon the lecture table. I once saw a lecturer and a roomful of three hundred students all violently holding their noses, in the effort to produce a smell sensation by mechanical stimulation. The result did not warrant the expenditure of energy.

Aronsohn's method of determining the olfactory qualities may be demonstrated by sets of three phials: exhaustion by camphor kills the scent of absolute alcohol, while it leaves that of musk practically unimpaired. But, apart again from the trouble of making up and renewing these sets, it must be remembered that scents readily diffuse in the lecture room, and cling for some time to the clothes of the students. Demonstrations of this sort are therefore liable to bring psychology into disrepute with other departments of the university.

V. Other Sensations.

For all the remaining sensations I employ apparatus only on the lecture table. Sensations of tendinous strain may be got from the clenched fist; sensations of articular pressure from the moved wrist; the muscle sensation proper must wait over for laboratory experiments. The sensation of dizziness may be obtained, briefly but clearly, from a quick jerk of the head to one side,—as if one were trying to throw one's head away. The tickling complex may be brought to mind, if not exactly reproduced, by light movement of a finger-tip over the palm of the other hand. A concomitant sensation of shiver may often be set up by the squeaking of the writing-chalk upon the blackboard. Hunger, thirst, nausea, muscular pain, lightness and oppression of breathing, tingling, itching, etc., must be left to memory or to chance experience.

These last paragraphs have a rather trivial appearance. I have, however, written out my own procedure, partly in the hope that some of my colleagues may be able to suggest better demonstrations from their teaching experience. In conclusion, I may say a word about models. I had meant in this paper to discuss the psychological use of the projection lantern; but limits of space forbid.

For vision, I use the large Auzoux eye model. For audition, I have the Auzoux ear model, Steger's large plaster

models of the internal ear (admirable demonstration pieces), and Helmholtz' mechanical model of drum-skin and ossicles. It is also worth while to make a rough model of the unrolled cochlea: the simplest materials are a wide tin tube, say 60 cm. long by 15 cm. in diameter, closed at the one end by a rounded cap (removable); a strip of stout white cardboard, of the same length and width as the tube, painted black over one half from the diagonal to the boundaries; and a narrower strip, with a bent-up foot, to represent Reissner's membrane. The model may be further elaborated, but is best made large and very simple.

I know of no psychologically adequate model of the sense-organs of the skin. All that one can do is to take some one of the ordinary physiological models, and paint or mould upon it the organs that one wishes to show. The mode of stimulation of the pressure and pain organs may be demonstrated by help of a thin board laid over a thickish block of sponge rubber.

In discussing the static sense, I have sometimes used, besides the Steger models, a large glass tube, expanded to a bulb near one end, and partially filled with a colored liquid. The remaining sense-organs do not require models, though certain of them (*e. g.*, muscle and tendon, the articular organs) require diagrams of a different sort from those found in the physiologies. I give in my *Primer of Psychology* (p. 48) a diagram which shows the mutual independence of the sensations of strain and of muscular contraction. Synaesthesia may be illustrated by painted diagrams, of the kind given by Galton in his *Inquiries into Human Faculty*.